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**"ELECTROCHEMICAL IMPEDANCE PATTERN RECOGNITION  
FOR DETECTION OF HIDDEN CHEMICAL CORROSION  
ON AIRCRAFT COMPONENTS"**

**Bi-Monthly Technical Progress Report Number 2**

**on**

**DOD SBIR Contract No. F49620-94-C-0043, DEF  
for the period August 15, 1994 - October 14, 1994**

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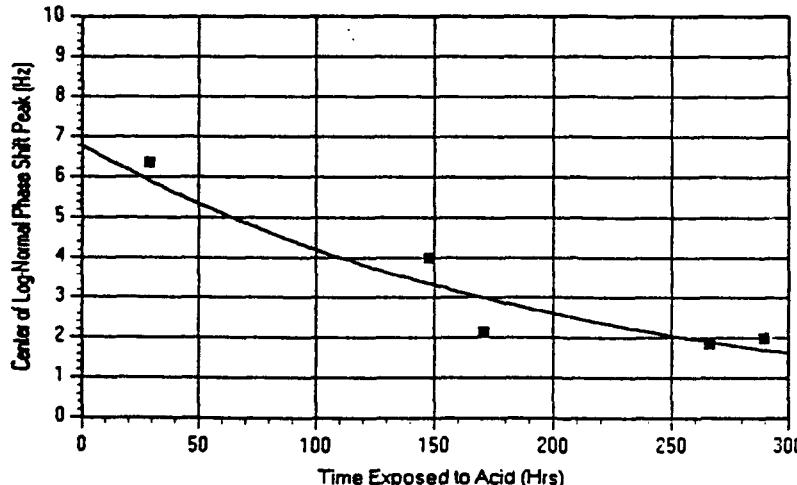
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Progress is presented for the program goal of developing diagnostic instrumentation for both detecting the presence and degree of hidden chemical corrosion on aircraft titanium and aluminum alloy components.

**Task 2** - Previously reported Fast Fourier Transform Electrochemical Impedance Spectroscopy (FFTEIS) techniques and hardware were applied to a matrix of Ti 15-3, Al 2024 or Al 7075 alloys fabricated during Task 1 to represent aircraft seams corresponding to simulated hidden corrosion sites. Metal-metal interface studied included Al 2024/Al 2024, Al 7075/Al 7075, Ti 15-3/Ti 15-3, Al 2024/Al 7075, Al 2024/Ti 15-3 and Al 7075/Ti 15-3. These samples were exposed to aqueous solutions, selected to closely imitate relevant corrosion conditions to which aircraft components might be exposed. Since SO<sub>x</sub> and NO<sub>x</sub> atmospheric emissions lead to the accumulation of both H<sub>2</sub>SO<sub>4</sub> and HNO<sub>3</sub>, alloy components were exposed to dilute (0.1M) solutions of these acids. In all cases the Log-normal peak phase shift, obtained from impedance data, was found to increasingly shift to lower frequencies as the corrosion time in acid media was increased. These changes in phase shift could be correlated with hidden corrosion phenomenon at the metal/metal interface using Scanning Electron Microscopy (SEM) techniques. For example, Figure 1 illustrates the change in phase shift centroid from a Ti 15-3/Al 2024 interface as a function of time when exposed to 0.1M H<sub>2</sub>SO<sub>4</sub>. SEM photographs of Ti 15-3 and Al 2024 before (Figure 2 A and B) and after (Figure 3A and B) exposure to 0.1M H<sub>2</sub>SO<sub>4</sub> for 289 hours are shown. These illustrate a correlation between measured impedance data and the occurrence of hidden corrosion at Ti 15-3/Al 2024 interfacial sites. This also demonstrated the technique as very sensitive for detecting and quantitatively measuring low levels of metal corrosion at such sites. Differences in alloy surface compositions before and after corrosion, as determined by energy dispersive X-ray analysis, indicated that majority alloy constituents were being preferentially attacked, resulting in enhanced concentrations of trace constituents. Correlation between SEM detected metal corrosion and FFTEIS phase shift will continue during the final stage of this program.

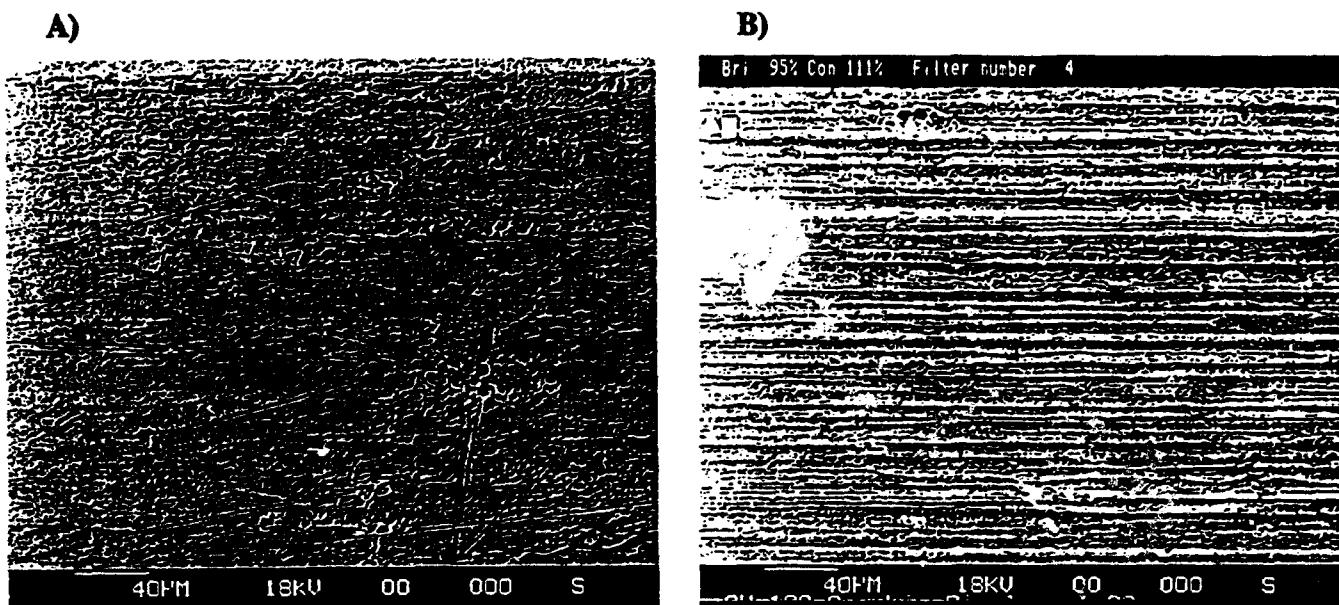
**Task 3** - Neural net training of impedance data has begun based upon NeuroShell II software. Determination of success in training as a function of data noise is being performed. Results will determine the degree of data smoothing required prior to presentation to the neural net. Neural net training initially correlating phase shift corrosion time will be correlated to the amount of metal corroded, in the final contract performance period in this task.

**Figure 1.** Change of hidden corrosion induced phase shift peak centroid with time in 0.1M H<sub>2</sub>SO<sub>4</sub> at Ti 15-3/Al 2024 interface.

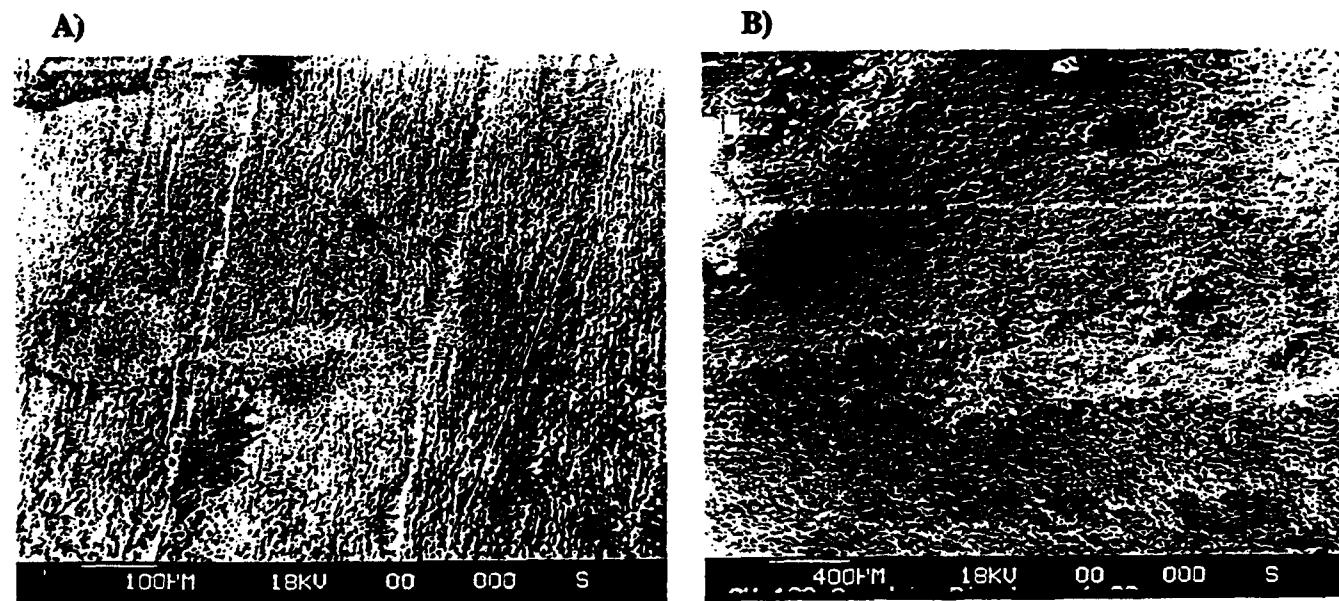


**Task 4** - Prototype component instrumentation hardware and software development is 75% com-

pleted. Program hardware software components are in place and integration of neural net functionality is in progress. A single board microprocessor controlled potentiostat has been designed, fabricated and incorporated as one component of the FFTEIS system. The previously reported amplification and filtering unit has also been interfaced to prototype instrument digital data acquisition hardware. Completion of neural net training and testing will meet Task 4 goals.



**Figure 2.** Scanning Electron Micrograph of A) Ti 15-3 and B) Al 2024 coupons prior to corrosion exposure in 0.1M H<sub>2</sub>SO<sub>4</sub>.



**Figure 3.** Scanning Electron Micrograph of A) Ti 15-3 and B) Al 2024 coupons from Al 2024/Ti 15-3 interface, following exposure to 0.1M H<sub>2</sub>SO<sub>4</sub> for 289 hours.